Supplementary Information

Wildfire smoke PM$_{2.5}$ and mortality in the contiguous United States

Yiqun Ma, Emma Zang, Yang Liu, Yuan Lu, Harlan M. Krumholz, Michelle L. Bell, Kai Chen

*Corresponding author: Kai Chen
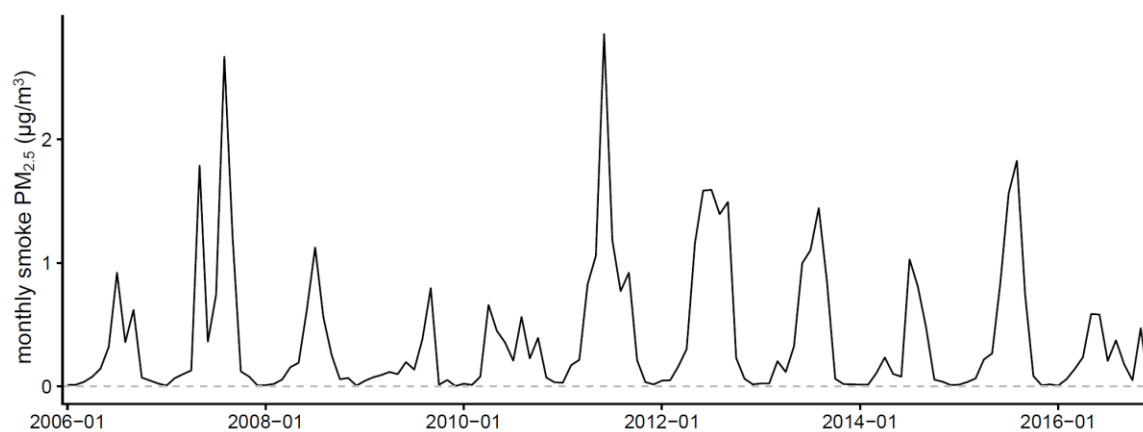Email: kai.chen@yale.edu

Fig. S1. Trend of average monthly smoke PM$_{2.5}$ concentrations for all U.S. contiguous counties from 2006 to 2016.
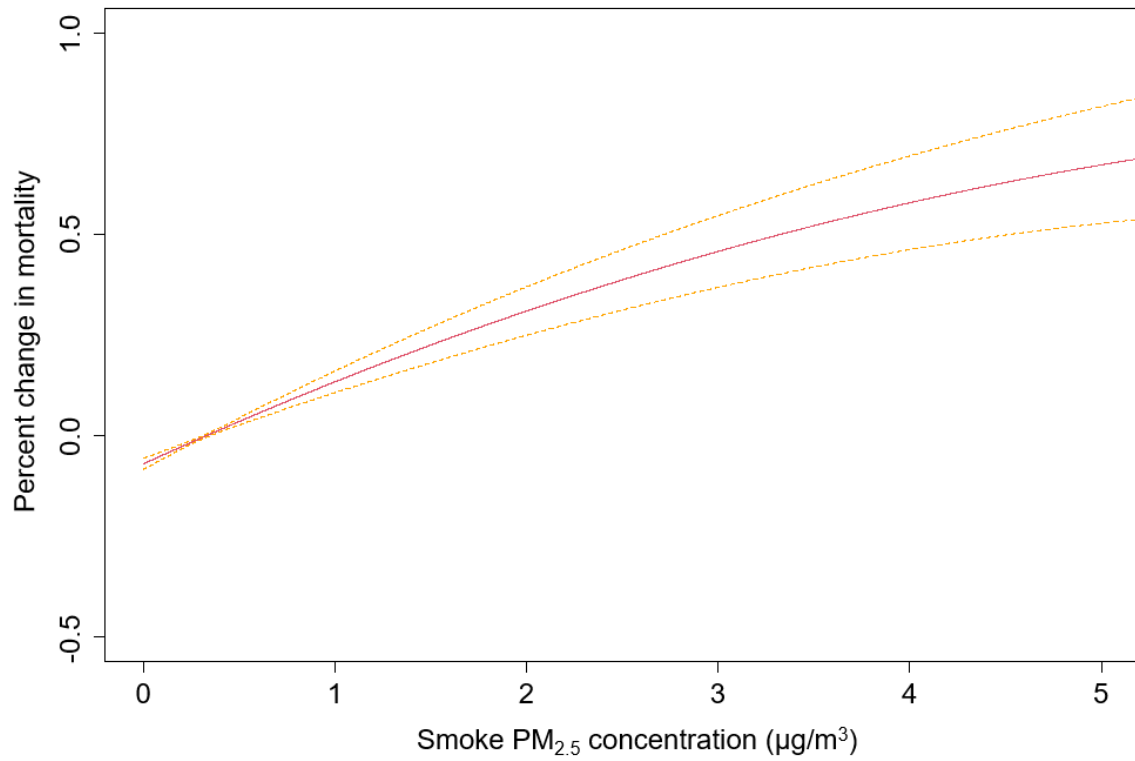
Fig. S2. Linearity test for the relationship between wildfire smoke PM$_{2.5}$ concentration and all-cause mortality risk. We used a natural cubic spline with three degrees of freedom for wildfire smoke PM$_{2.5}$ concentration in the model as a linearity test. This plot shows the estimated near-linear exposure-response curve for all-cause mortality, within the 0.5th -99.5th percentile range of smoke PM$_{2.5}$ concentration.
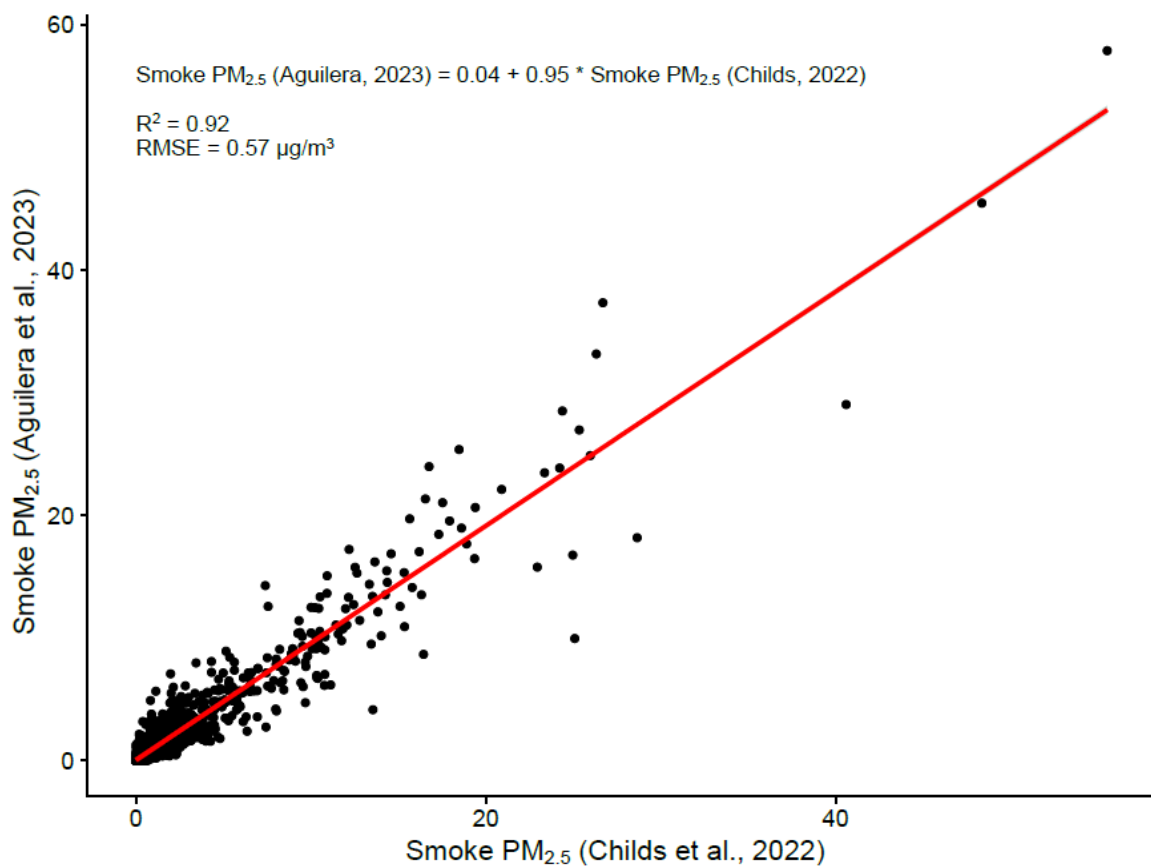
Smoke PM$_{2.5}$ (Aguilera, 2023) = 0.04 + 0.95 * Smoke PM$_{2.5}$ (Childs, 2022)

$R^2 = 0.92$
RMSE = 0.57 µg/m^3

Fig. S3. External validation of the wildfire smoke PM$_{2.5}$ estimates. We validated the wildfire smoke PM$_{2.5}$ estimates we obtained from Childs et al., 2022 (1) against a recent wildfire-specific PM$_{2.5}$ model in California developed by Aguilera et al., 2023 (2), using estimates from 2006 to 2016. This external validation showed a great consistency between the monthly county-level predictions from these two models, with an R-squared (R^2) value of 0.92 and a root-mean-square error (RMSE) of 0.57 µg/m^3.

Table S1. Monthly descriptive statistics for all 3,108 contiguous U.S. counties from 2006 to 2016

	Mean (SD*)	Min	Median (IQR†)	Max
Environmental factors				
Wildfire smoke PM$_{2.5}$ (μg/m^3)	0.39 (0.95)	0	0.05 (0.38)	70.95
Non-smoke PM$_{2.5}$ (μg/m^3)	7.90 (3.27)	0	7.76 (4.17)	43.68
Air temperature (°C)	12.72 (9.98)	-20.58	13.62 (15.64)	35.41
Mortality counts				
All-cause mortality	67.79 (182.03)	0	23 (44)	6197
Cardiovascular	21.51 (61.61)	0	7 (14)	2331
Respiratory	6.61 (16.82)	0	2 (5)	710
Mental	3.33 (8.80)	0	1 (3)	296

*SD: standard deviation
†IQR: interquartile range

Table S2. Results from sensitivity analyses

Model	Percent change in mortality (95% CI)[*]
Main model	0.14 (0.11, 0.17)
Adjustment for NO_2	0.08 (0.05, 0.11)
Adjustment for O_3	0.18 (0.15, 0.21)
Adjustment for dew point temperature	0.08 (0.05, 0.11)
Without adjustment for non-smoke $PM_{2.5}$	0.14 (0.10, 0.17)
Temperature df=4[†]	0.16 (0.13, 0.19)
Temperature df=6	0.15 (0.12, 0.18)
Smoke $PM_{2.5}$ lag 1 month	0.12 (0.09, 0.15)
Smoke $PM_{2.5}$ lag 2 months	0.05 (0.02, 0.08)
Restrict analysis to counties with high smoke $PM_{2.5}$[‡]	0.15 (0.12, 0.18)

[*]Estimated percent change in all-cause mortality per 1-$\mu g/m^3$ increase in wildfire smoke $PM_{2.5}$ concentration from different models; CI: confidence interval

[†]df: degree of freedom

[‡]Restricting the analysis to counties that have at least one day of high smoke $PM_{2.5}$ exposure (20 $\mu g/m^3$; 2403 counties).

References

1.   Childs ML*, et al.*, Daily local-level estimates of ambient wildfire smoke PM2.5 for the contiguous US. *Environ Sci Technol* 56(19):13607-13621 (2022).
2.   Aguilera R*, et al.*, A novel ensemble-based statistical approach to estimate daily wildfire-specific PM2.5 in California (2006-2020). *Environ Int* 171:107719 (2023).